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POSSIBLE SILURIAN TILLITE IN SOUTHEASTERN BRITISH COLUMBIA

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From the eastern slopes of the Purcell Range, in the vicinity of Lake Windermere, the view across the deep depression known as the Rocky Mountain trench to the Rocky Mountains on the east, shows a series of bands of rocks varying in color and running roughly parallel to the trench. One of these is a red conglomerate, which can be traced almost uninterruptedly for ten miles between the Sinclair River and Shuswap Creek, both of which are tributary to the Columbia River in the Rocky Mountain trench. The red formation was examined in two localities, and in a third a yellow conglomerate was found, which is undoubtedly a part of the same formation. In the last instance evidence was found which points toward a glacial origin of the conglomerate.

The conglomerate was first studied at Sinclair Springs. Here an outcrop of red rock, with a dip of about 90°, forms a high wall running down one side of the canyon and up the other (Fig. 1). Closer examination shows that the rock is not made up entirely of red material, but consists of bowlders, which are predominantly red, imbedded in a yellow calcareous matrix. The bowlders are limestone with the exception of a very few pieces of quartzite. The limestone varies considerably, having such varieties as purple, black, white crystalline, blue with white veins, and gray. The bowlders are mostly sub-angular and in some cases are as large as four feet in diameter (Fig. 2). The material of the conglomerate is unassorted, and shows no trace of stratification. Two bowlders were seen which had polished surfaces. It was difficult to remove the bowlders from the matrix, and the exposed surfaces of the bowlders were so weathered that any striations they may have once possessed have been destroyed.

The thickness of the conglomerate is about 200 feet. Against it on the east, with apparent conformity, is gray limestone. This contains a scattering of pebbles in the portion next the conglomerate. Six hundred and fifty feet below the top of the limestone is a bed containing fossils of Richmond age. As these beds are vertical, the age relations of the conglomerate to the limestone are not shown by the structure, but since somewhat older Ordovician faunas occur farther east, the conglomerate is known to be 650 feet above strata containing the Richmond fauna. Above the bowlder bed there is a break in the succession, and above the break is massive crystalline limestone in which no fossils were found. Farther west there is severe faulting which cuts out further evidence from fossils on that side. From the evidence on the east it was concluded that the age of the formation probably is Silurian because of the 650 feet of limestone between it and the fossil bed which represents the top of the Ordovician.

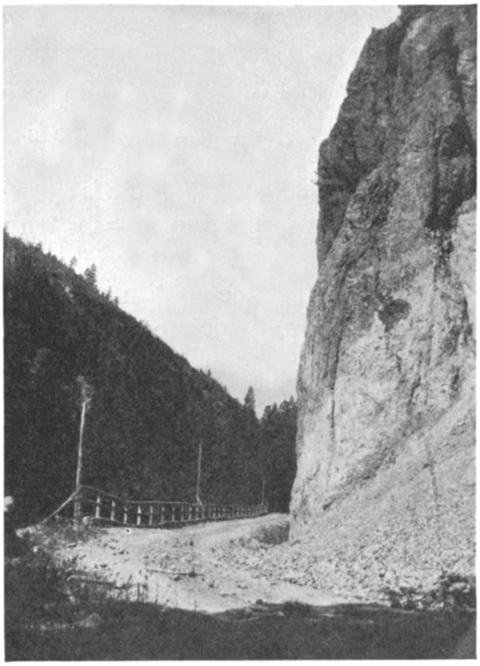

FIG. 1.—The red conglomerate near the Sinclair Hot Springs

Two miles up the canyon of Shuswap Creek the southward continuation of the formation was examined and found to be practically identical with that seen at Sinclair Springs. The bowlders are not so large on the average, but are equally angular and unrounded. In two places there are thin lenses of crumpled strata included in the formation. Both of these were only a few inches thick and did not extend more than 4 or 5 feet before being cut off by bowlders. The formation here is 150 feet thick. To the west there is crystalline limestone very similar to that found on the same side at Sinclair Springs. On the east there is a thin bed of quartzite, followed by massive limestone. To the south, up Windermere Creek in the vicinity of the Blue Lakes, there is conglomerate in direct line with the red bowlder bed. Here the character of the bowlders is quite different, as are also the distribution of the outcrops and the type of weathering, but there is sufficient evidence to show that the two conglomerates are parts of one formation.

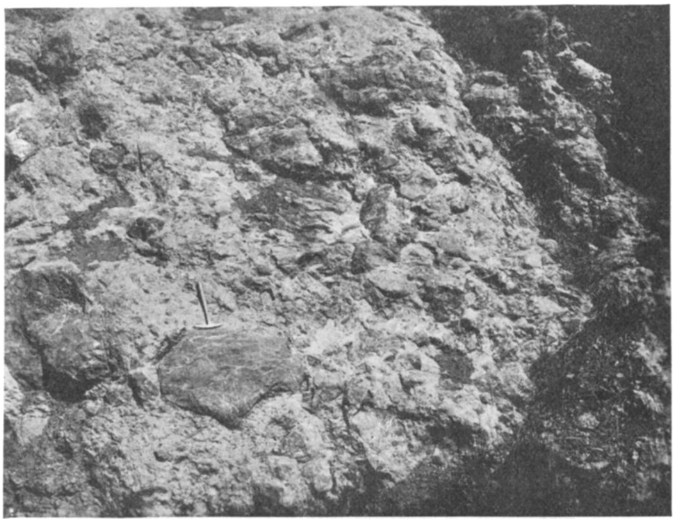

FIG. 2.—A typical section of the conglomerate. The hammer illustrates the size of the bowlders.

The formation in Windermere Creek valley is probably 400 or 500 feet thick and extends along the north side of the canyon for at least three-quarters of a mile. It is in the form of an anticline plunging to the south, and disappears in that direction.

The bowlder bed here consists of a firmly cemented aggregation of limestone, quartzite, and shale blocks with a few fragments of igneous rocks. Limestone is the most abundant constituent, but in some places quartzite bowlders predominate. Many of the pebbles and bowlders are distinctly faceted. Many of them are polished and some rounded as if by stream action. In some cases the quartzite surfaces are so polished as to be dazzling in the sunlight. Markings which suggest glacial striations were found on at least one bowlder. A large block of quartzite was seen to have on its surface a distinct gouge about ten inches long, three inches wide, and half an inch deep. A number of quartzite pebbles had concave surfaces. Evidence from fossils in the bowlders indicates the age of the conglomerate to be younger than Richmond.

The contact of the bowlder bed with the underlying calcareous shale is distinctly seen. The topmost layer of the shale is contorted and contains pebbles ranging up to six inches in diameter. They undoubtedly came from the same source as the overlying conglomerate and indicate that the shale was soft when the conglomerate was deposited.

The bowlder bed is overlaid to the west by massive limestone, with a slight gradation between the two. It is difficult to find the contact because it is covered by débris in most places.

Before considering the evidence that the formation is tillite, other possible modes of origin may be considered. Is the conglomerate in question (1) a stream conglomerate, (2) an autoclastic breccia, or (3) an undercliff breccia? The size and sub-angularity of the bowlders are difficult to explain if the conglomerate is fluviatile. Such bowlders are commonly found only in the valleys of mountain streams. As there is no evidence for a change in dip between the underlying and overlying limestone at Sinclair Springs, it is very improbable that there was any intervening uplift which could have led to the development of mountain streams. Further, the gradation between the bowlder bed and the limestone shows that the conglomerate could not have been deposited by mountain torrents.

Autoclastic breccias are more or less local phenomena. They are generally not confined to one stratigraphic horizon, but are likely to cross bedding planes, while the formation in question constitutes a distinct horizon traceable for a number of miles. The diversity of types of rock among the bowlders in the Windermere Creek occurrence is not characteristic of an autoclastic breccia, and the thickness of the formation is also against this interpretation.

Undercliff breccias have angular unsorted material such as found in this formation, but the possibility of adjacent cliffs at this time is slight, because of the gradation into overlying and underlying limestone, which shows only slight interruption of marine conditions. The great continuation of the formation both along the range and in a vertical direction (it has a known vertical range of more than 3,000 feet) are altogether against a cliff-base origin.

On the other hand, evidence for glacial action is strong. It includes (1) the finding of probable striations, (2) the sub-angularity of the bowlders, (3) the distinct faceting of some of the bowlders, (4) the heterogeneous mixture of the bowlders without assortment or stratification, (5) the occurrence of grooving and concave faces on pebbles, and (6) the occurrence of Silurian tillite in southeastern Alaska,[1] 900 miles away, also is significant.

Thus it seems possible that glacier ice existed at this period in British Columbia and southeastern Alaska. Since there are marine deposits on both sides of the formations in Alaska as well as in British Columbia, it is possible that the glaciers came out into shallow seas in these places. The absence of weathering at the top of the conglomerate points to encroachment of the sea before such weathering took place. The gradation into limestone in several instances in British Columbia suggests that icebergs coming from the retreating or advancing ice fronts distributed occasional bowlders among the limestone deposits. It is not surprising that this formation should continue over such great distance without a break, when it is considered that sea deposits covered it before it could be attacked by erosion.

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[1] E. Kirk, *Amer. Jour. Sci.*, Fourth Series, September, 1918, p. 511.